

# **Switching Transients on a Southern Company 500 / 230 kV Auto- transformer: Examples from Project to Present Date**

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NEETRAC High Voltage Laboratory

Presentation courtesy of The Southern Company

Contributions from JMX Services, Inc

## Switching transients at 500 / 230 kV auto-transformer

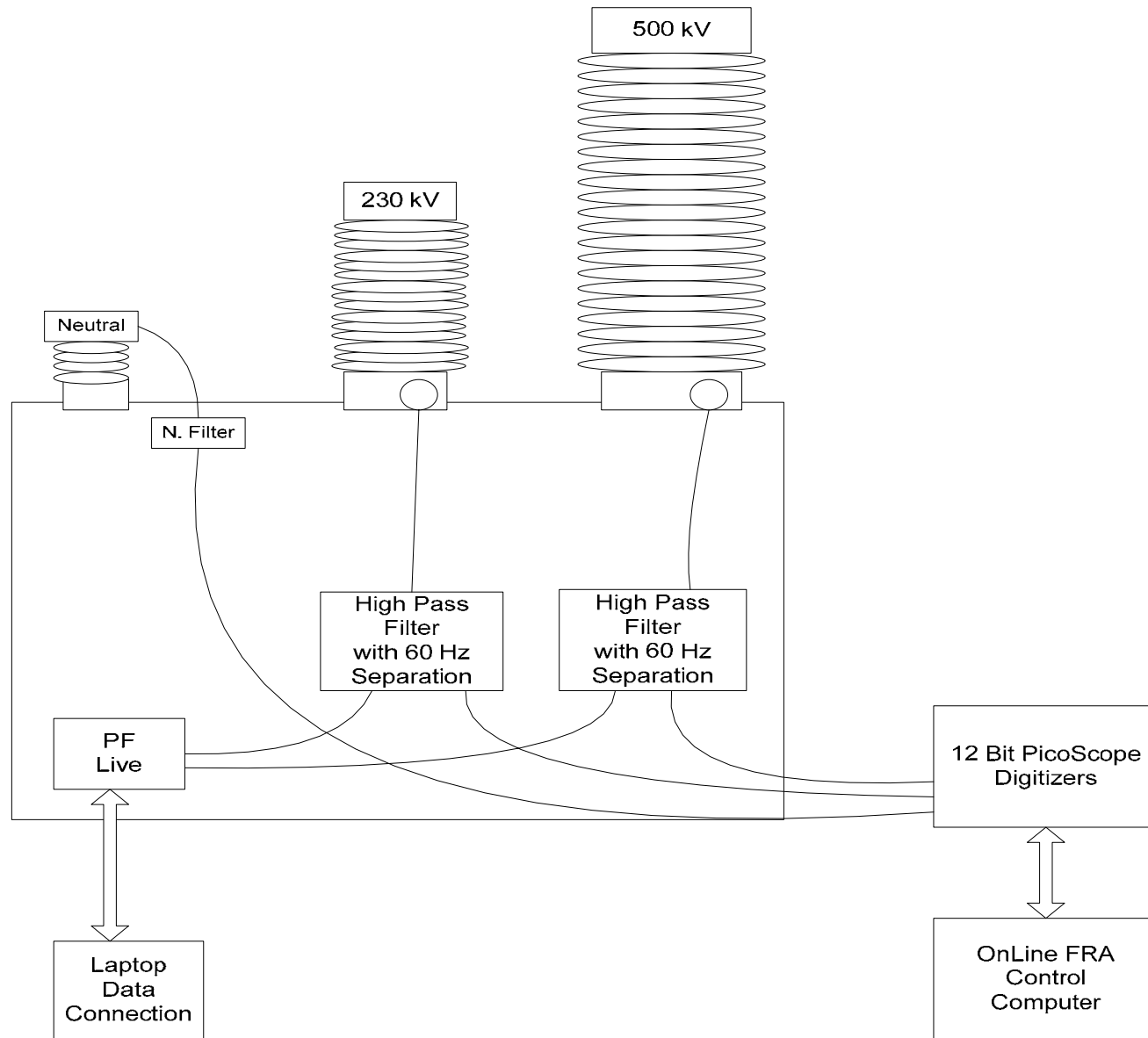
- Laboratory withstand & calibration tests on a field installed laboratory grade voltage divider
- Transients due to de-energizing 950 ft. of 500 kV bus with motorized disconnect switch
- On-line transfer function of 500 / 230 kV auto using same disconnect switch transient
- Show comparison of on-line transfer function to baseline off-line transfer function
- Show transients for switching 500 / 230 auto trans out of service and switching auto back in service
- Show frequency content of a low level area lightning strike typically used for on-line FRA calculation

**Wideband Voltage Divider  
Near 230 kV X1 Bushing**









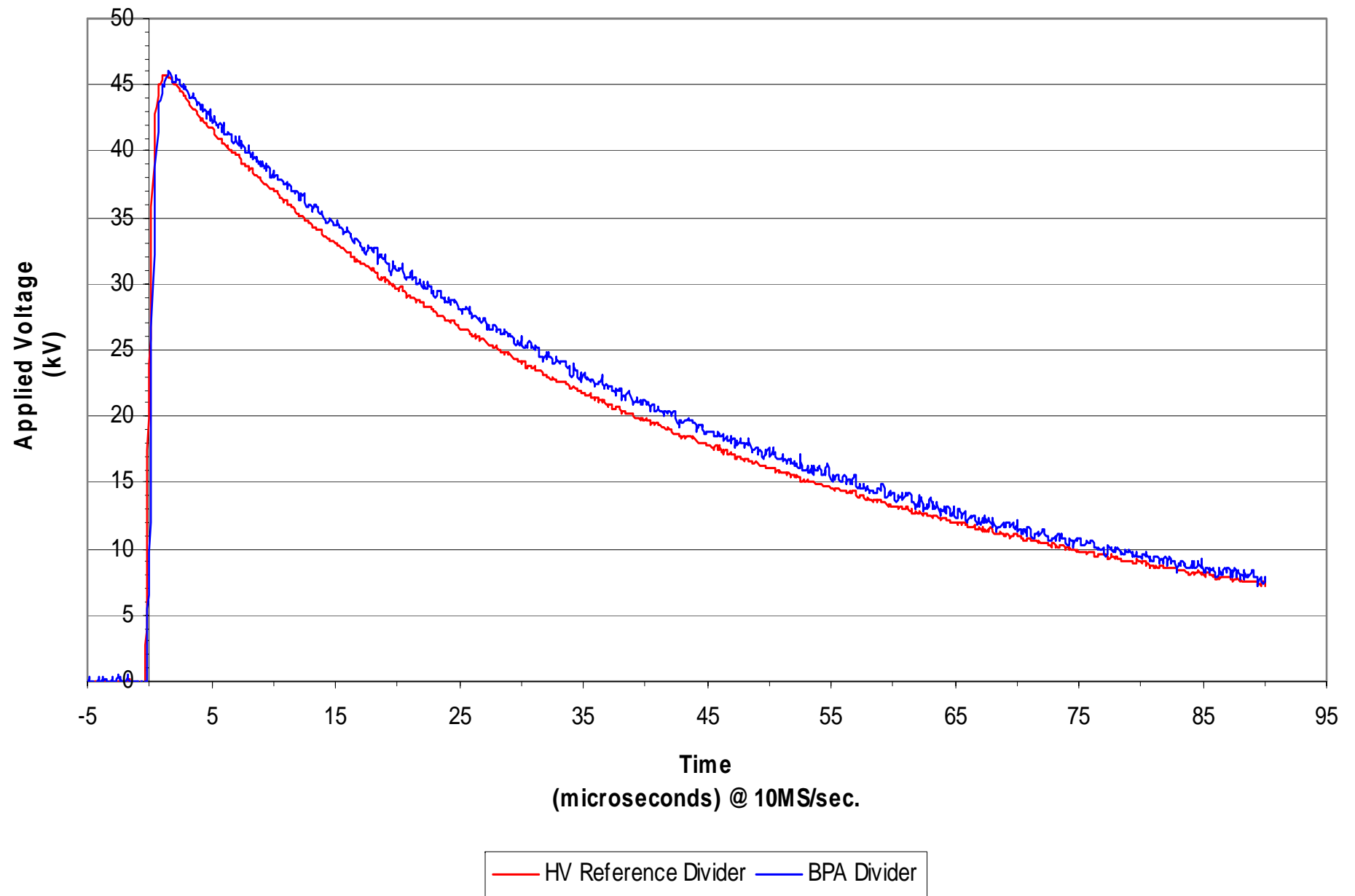
**ON-Line FRA System Layout  
(a typical phase)**

**Figure 1**

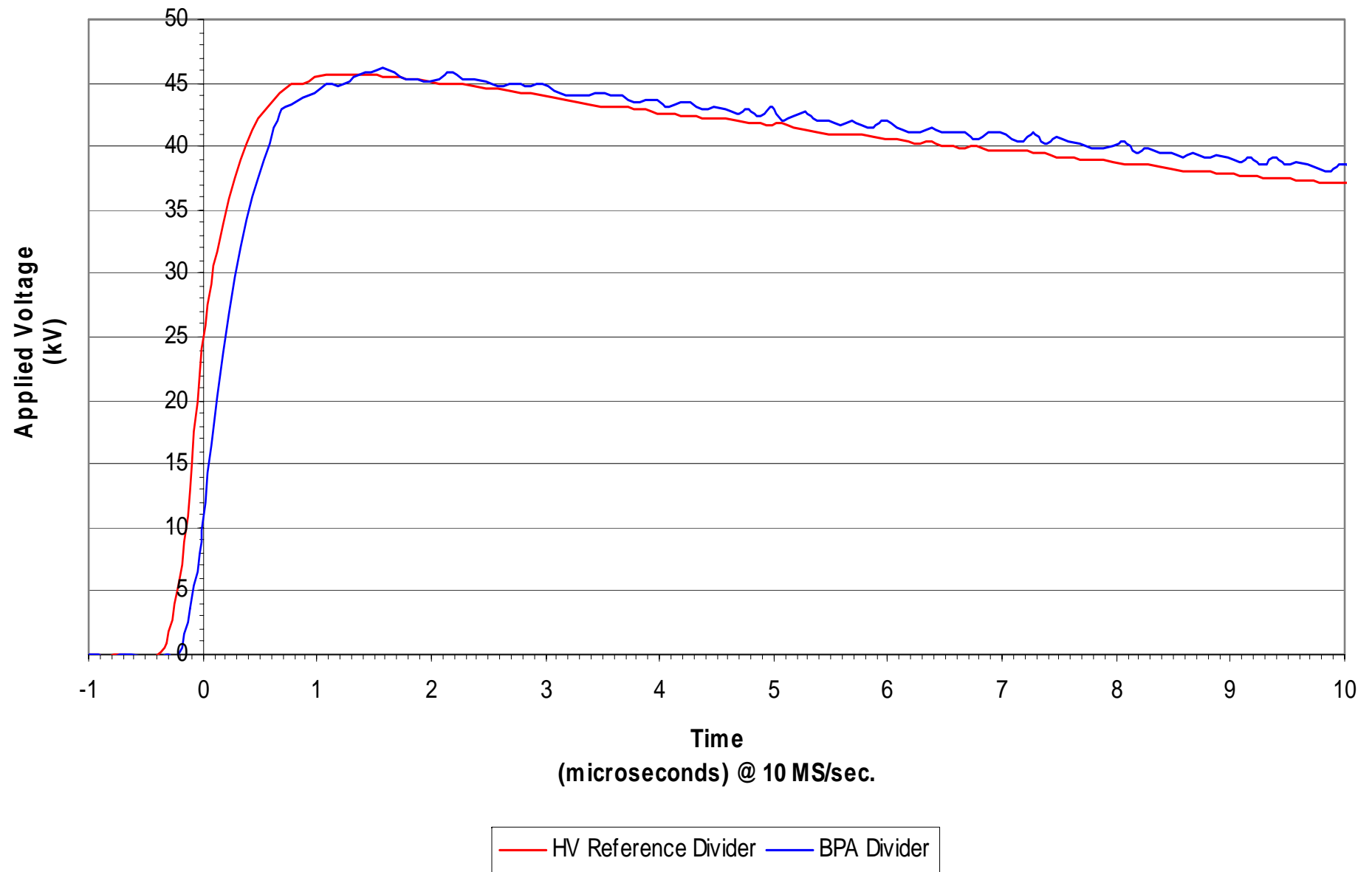
# Laboratory Tests Performed

- ac 60 Hz ratio 40 kV - 300 kV (**75,007:1**)
- Partial Discharge @ 300 kV (2 PC)
- Withstand of 3+ & 3-, 1 MV lightning impulses (**72,973:1** compared to laboratory 2.1 MV impulse divider)
- Time domain comparisons 45 kV - 200 kV impulse with laboratory reference voltage divider (**76,015:1**)

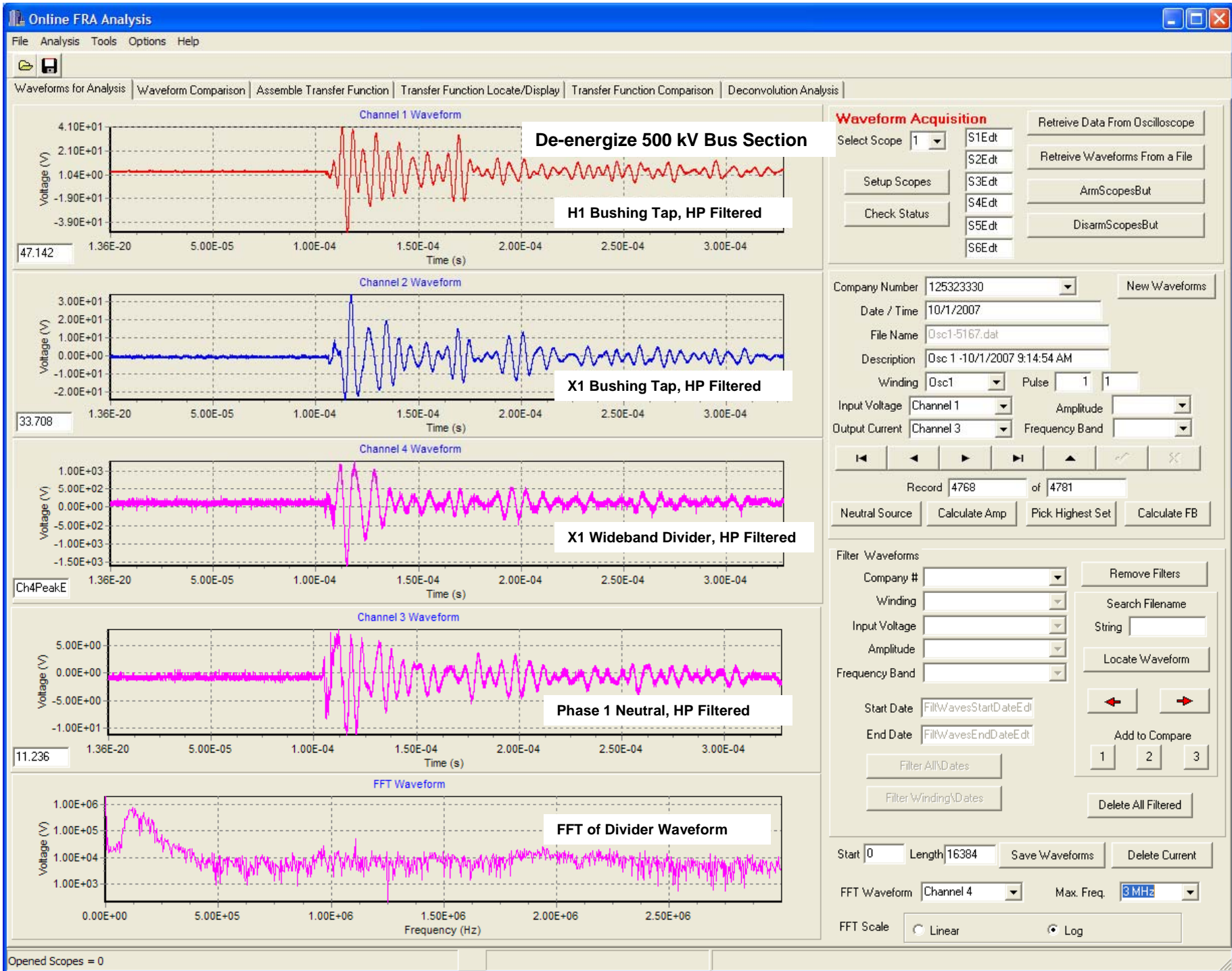
## Time Domain Calibration Check of BPA Voltage Divider

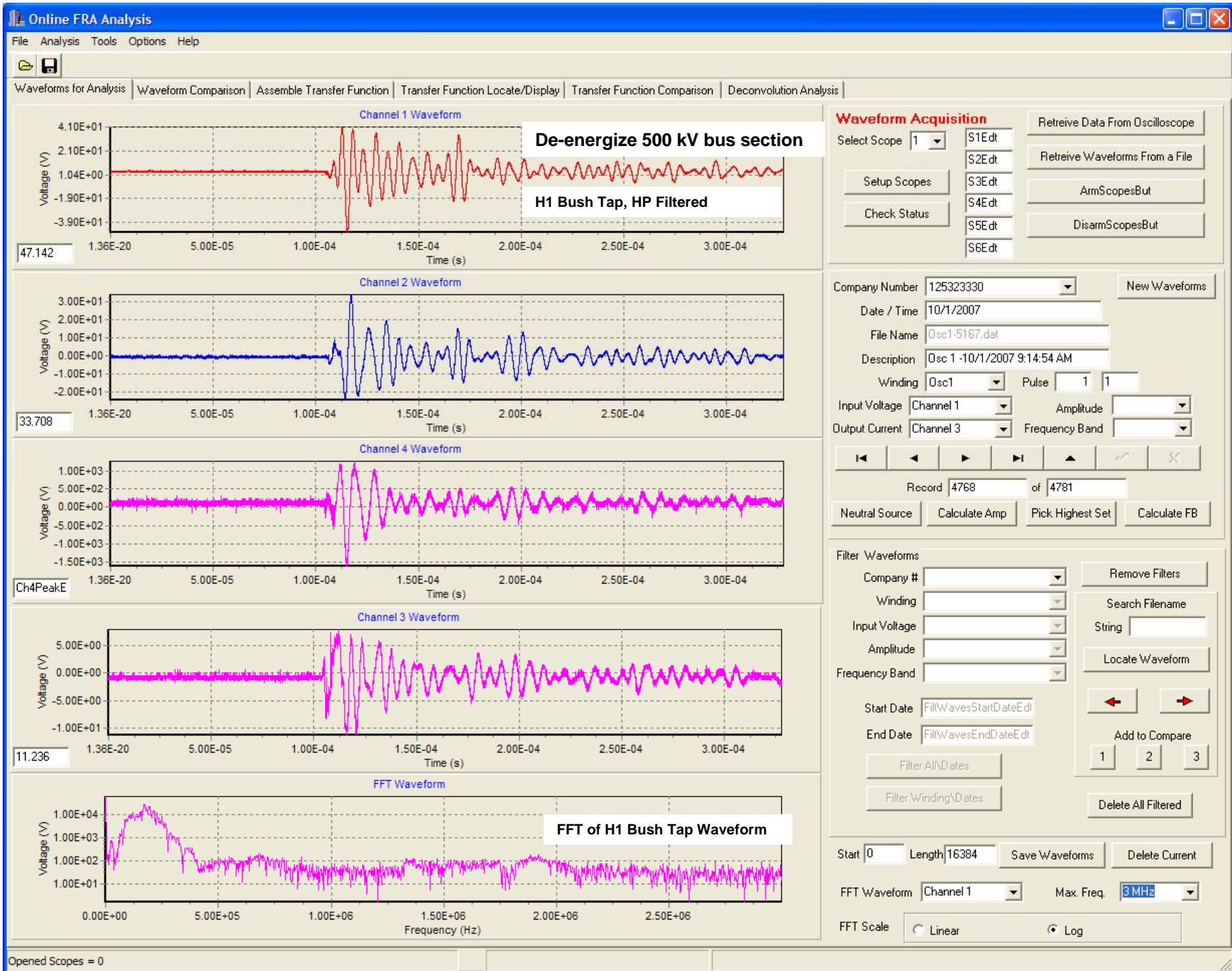


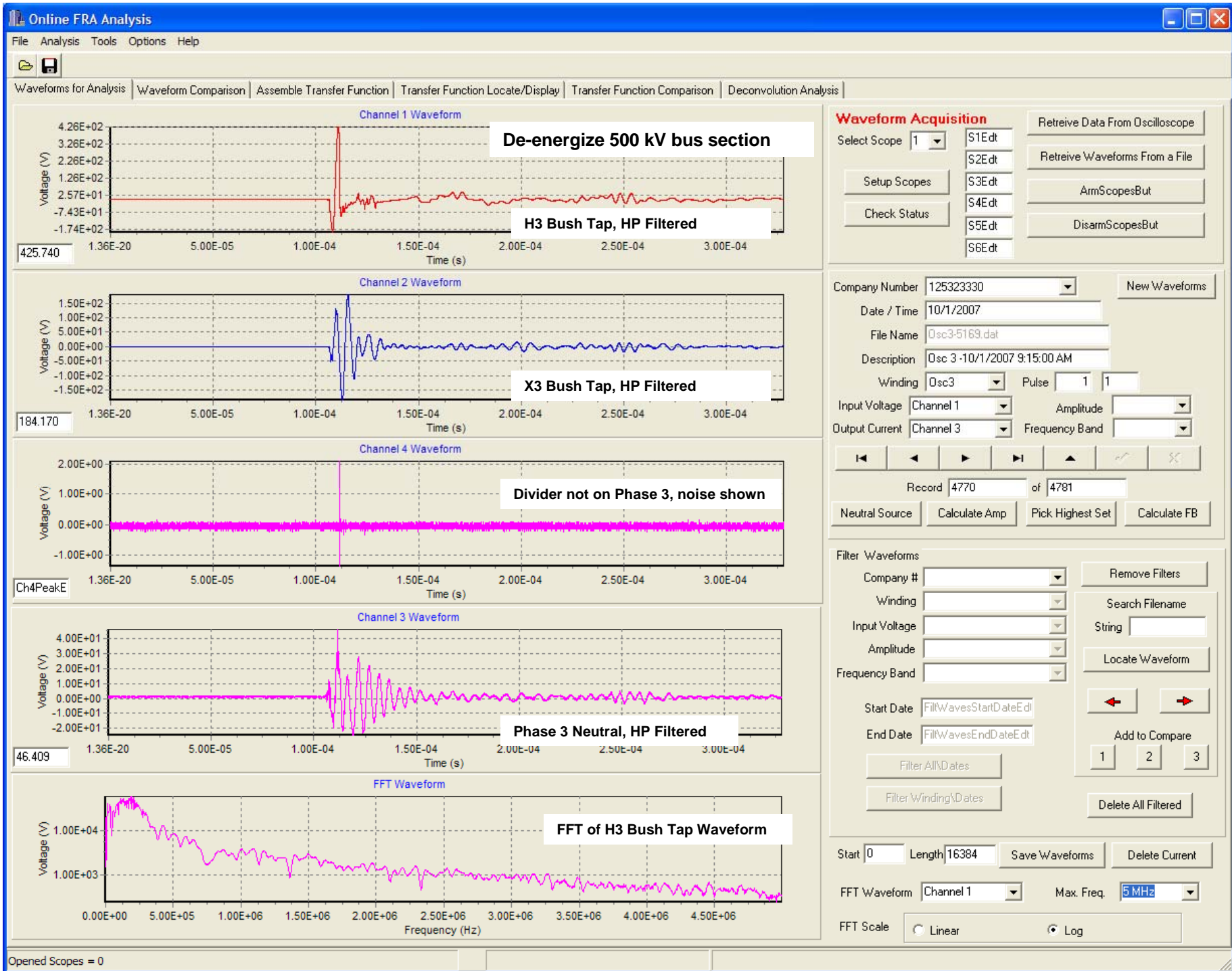
**Time Domain Calibration Check of BPA Voltage Divider**  
**[zoom in on front & peak of impulse]**



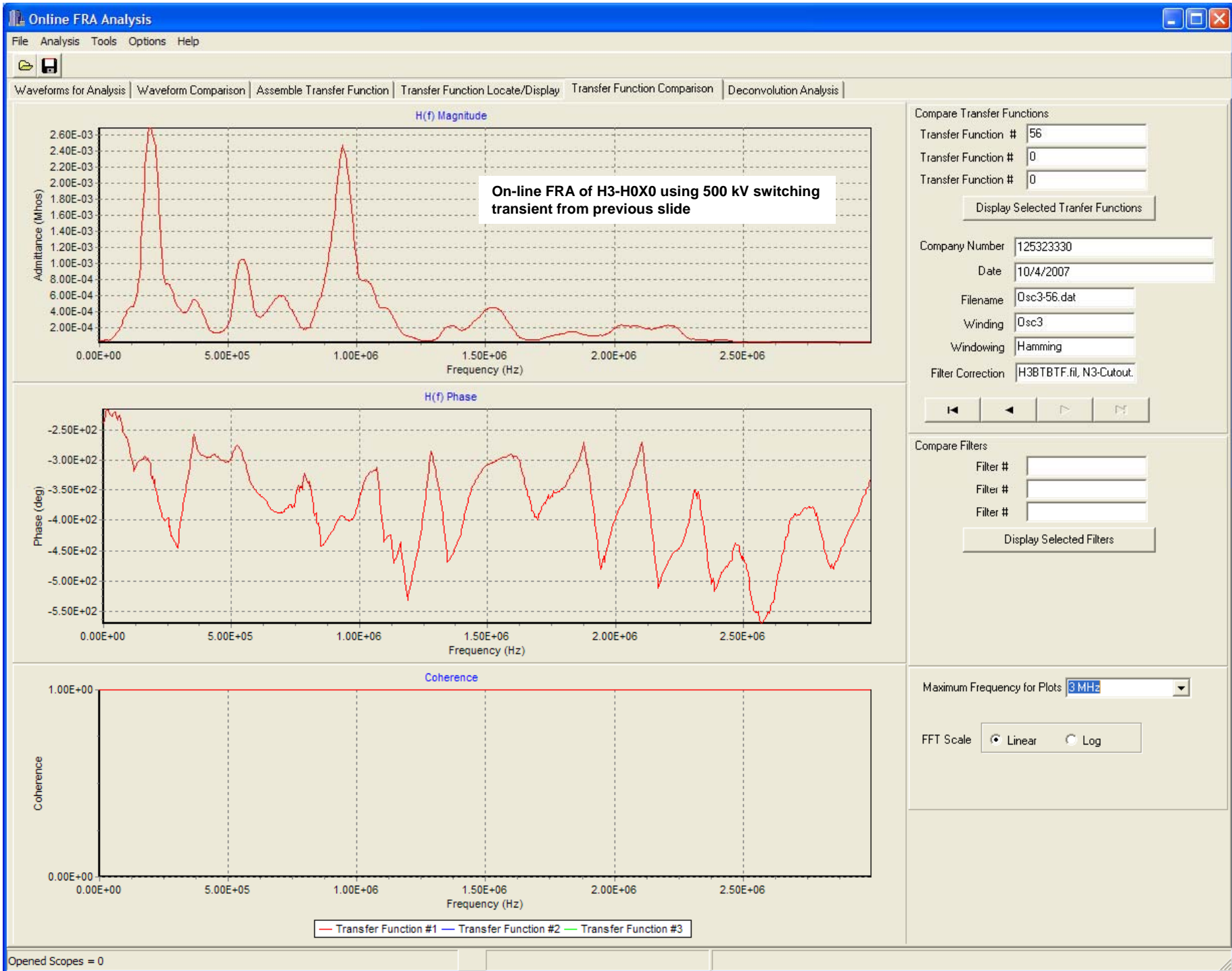













## Winding Comparisons - 125323330-R

H Phase	WND	X Phase	WND
H1_H0X0-H2_H0X0	54.6	X1_H0X0-X2_H0X0	98.5
H2_H0X0-H3_H0X0	171.0	X2_H0X0-X3_H0X0	110.7
H3_H0X0-H1_H0X0	142.8	X3_H0X0-X1_H0X0	82.8

 Generate Report...

Frequency Range

☐ 0.1 ☐ 0.5 ☒ 3.0

Plot: H Phase

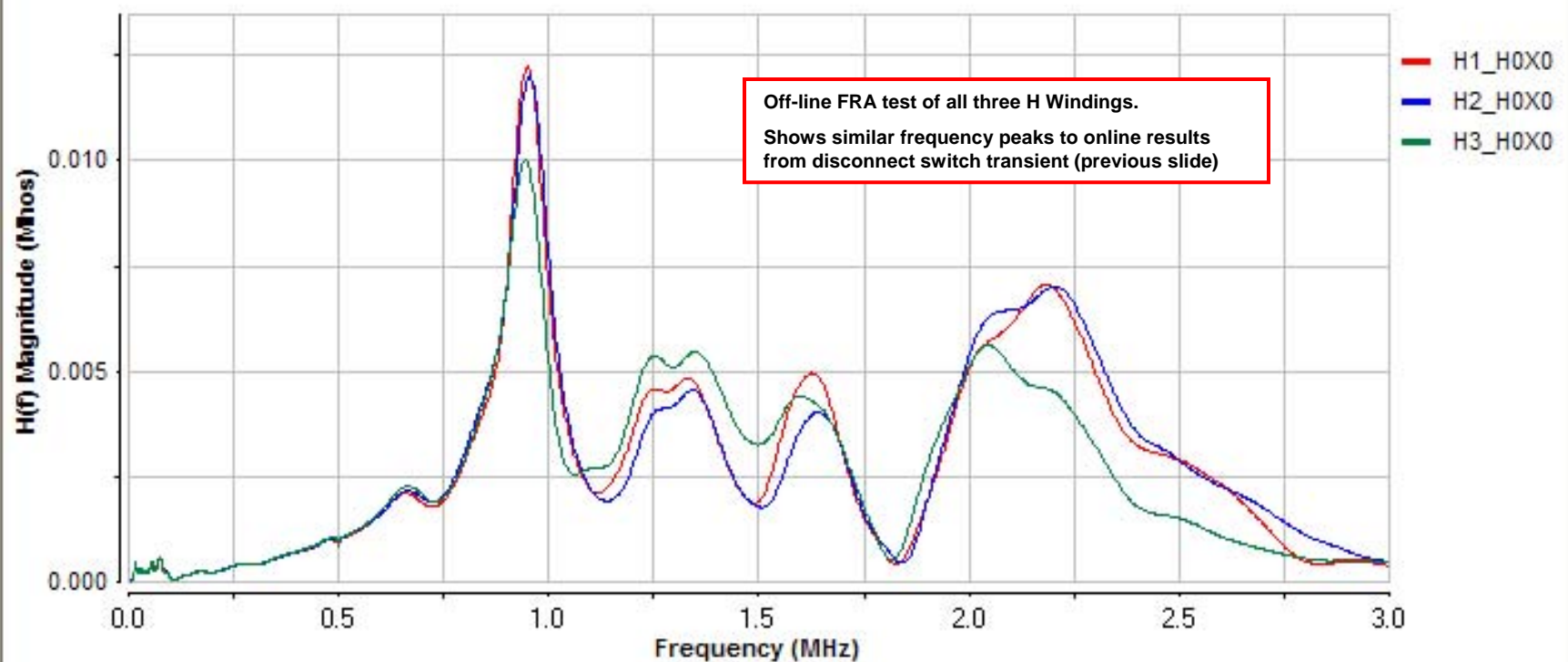
Date: 2/7/2006  
4:11:41 PM

Type: 500 / 230 kV, Auto, 672 MVA

Additional Analysis ...

☐ Display In DB

### Transfer Function Magnitude Comparison



Transfer

Difference

Phase

Coherence

 Close


 Print Plot

## Winding Comparisons - 125323330-R

H Phase	WND	X Phase	WND
H1_H0X0-H2_H0X0	13.0	X1_H0X0-X2_H0X0	22.5
H2_H0X0-H3_H0X0	19.5	X2_H0X0-X3_H0X0	22.7
H3_H0X0-H1_H0X0	23.7	X3_H0X0-X1_H0X0	18.0

H3\_H0X0 = 65.9% Asym.

X2\_H0X0 = 25.8% Asym.

 Generate Report...

Frequency Range

☐ 0.1 ☒ 0.5 ☐ 5.0

Plot: H Phase

Date: 2/7/2006  
4:11:41 PM

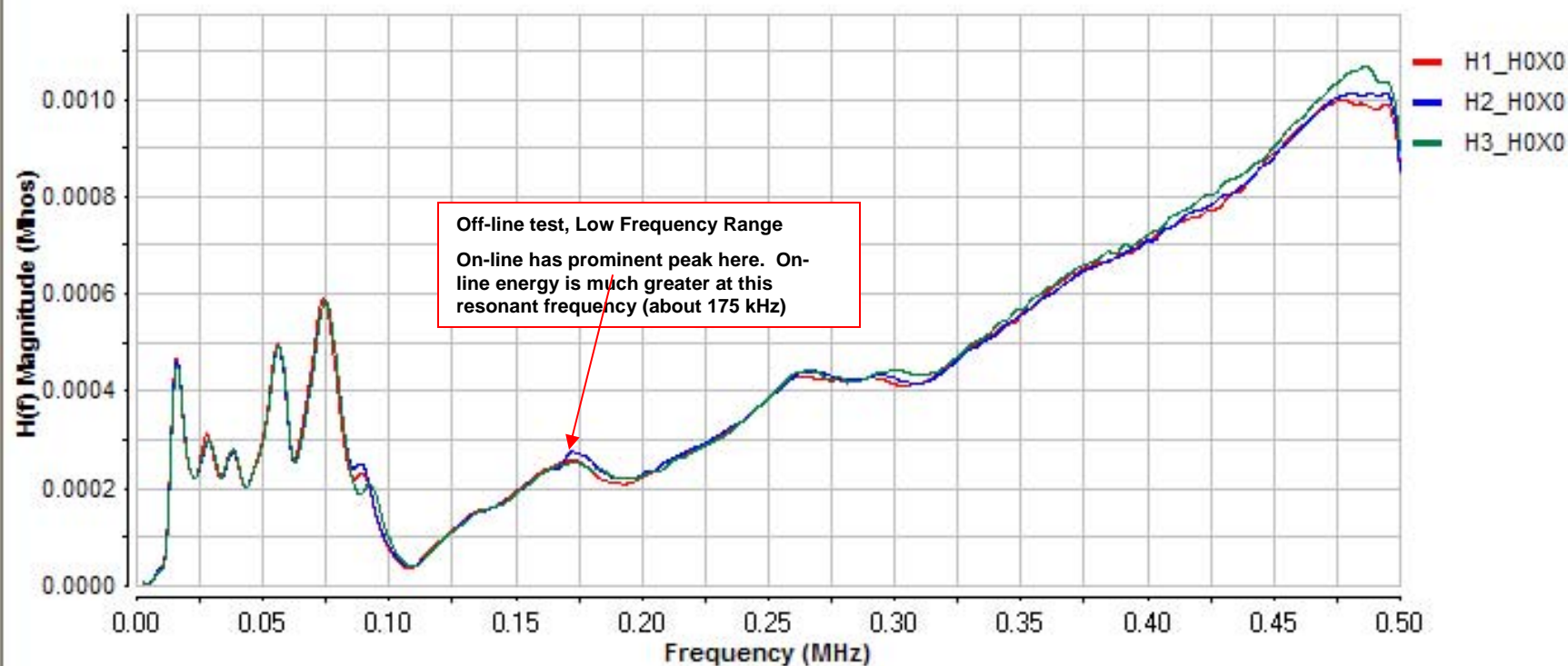
Type: 500 / 230 kV, Auto, 672 MVA

EVALUATION: NO SIGNIFICANT DEFORMATION DETECTED

Additional Analysis ...

☐ Display In DB

### Transfer Function Magnitude Comparison

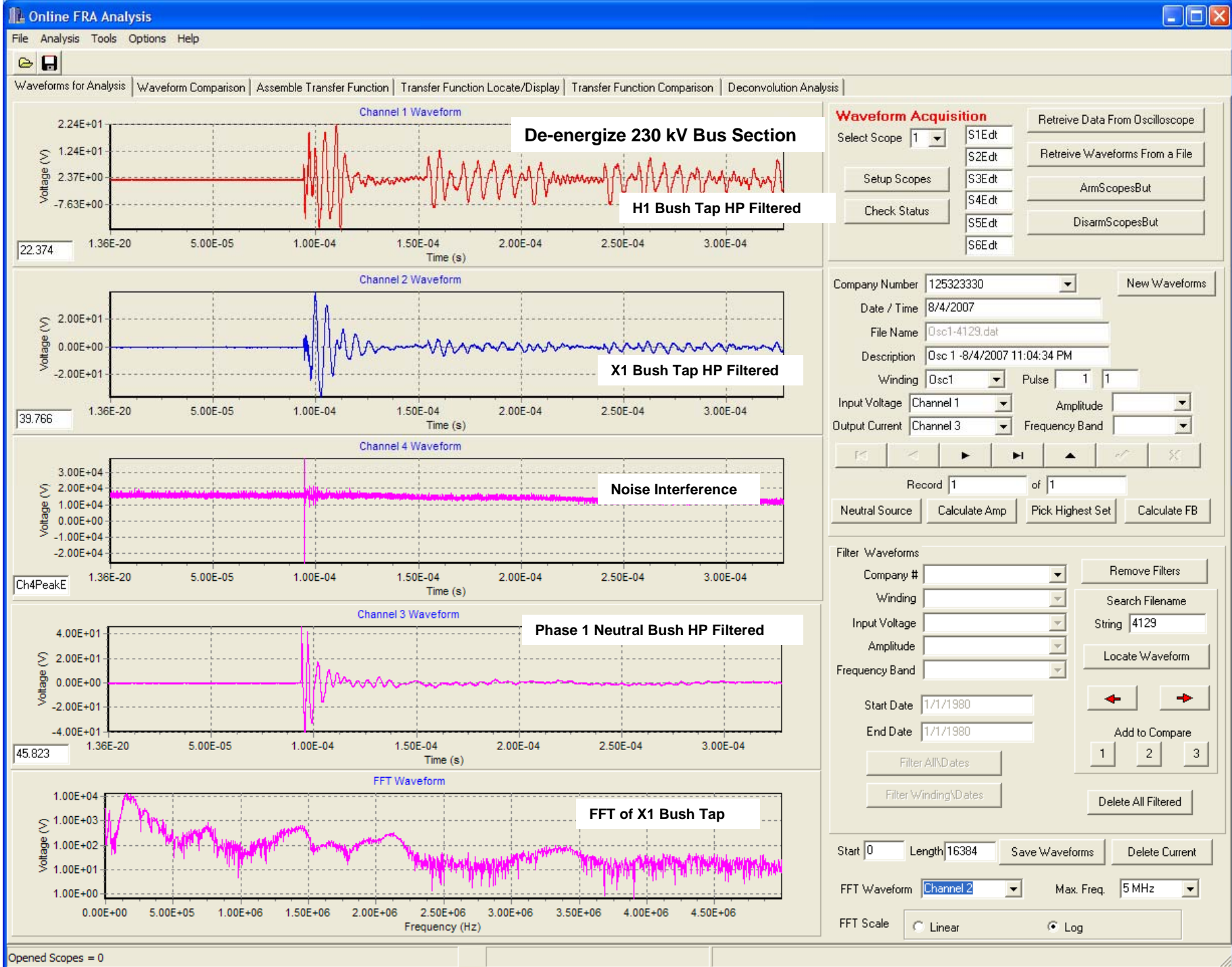


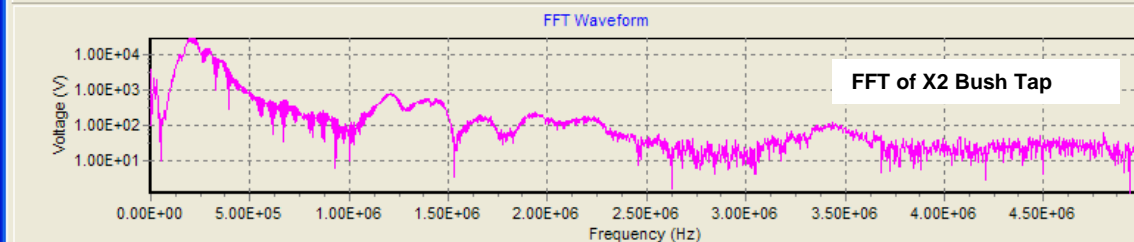
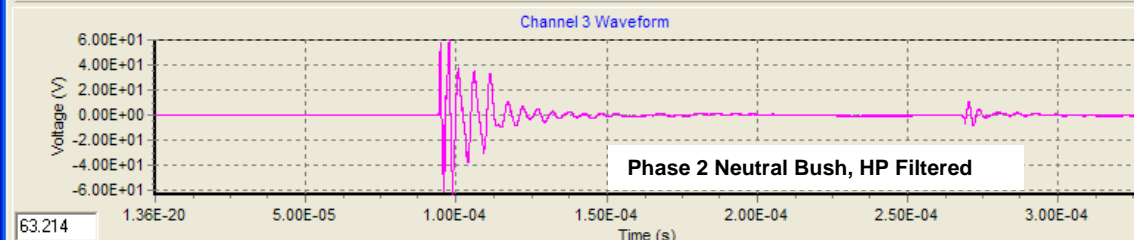
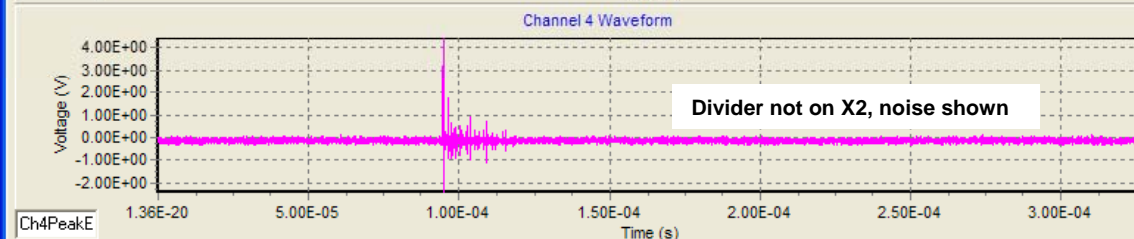
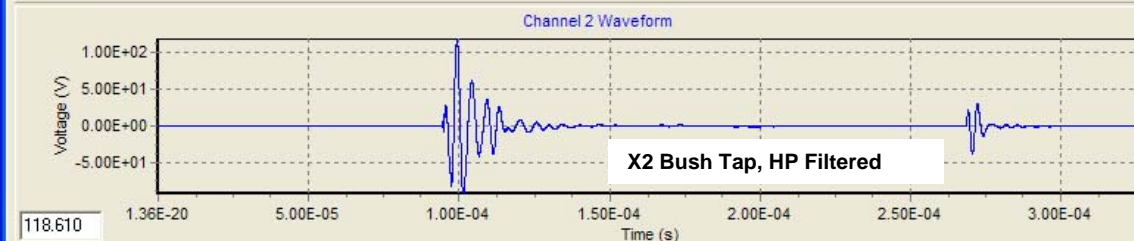
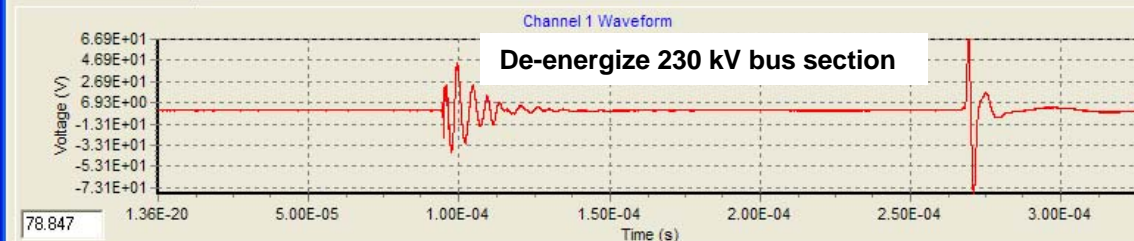
Transfer Difference Phase Coherence

 Close

 Print Plot







## Waveform Acquisition

Select Scope 1

S1Edt

S2Edt

Setup Scopes

S3Edt

Check Status

S4Edt

S5Edt

S6Edt

Retrieve Data From Oscilloscope

Retrieve Waveforms From a File

ArmScopesBut

DisarmScopesBut

Company Number 125323330

New Waveforms

Date / Time 8/4/2007

File Name Osc2-4130.dat

Description Osc 2 -8/4/2007 11:04:37 PM

Winding Osc2

Pulse 1 1

Input Voltage Channel 1

Amplitude

Output Current Channel 3

Frequency Band



Record 1 of 1

Neutral Source

Calculate Amp

Pick Highest Set

Calculate FB

## Filter Waveforms

Company #

Remove Filters

Winding

Search Filename

Input Voltage

String 4130

Amplitude

Locate Waveform

Frequency Band

Start Date 1/1/1980



End Date 1/1/1980

Add to Compare

Filter All\Dates

1 2 3

Filter Winding\Dates

Delete All Filtered

Start 0 Length 16384

Save Waveforms

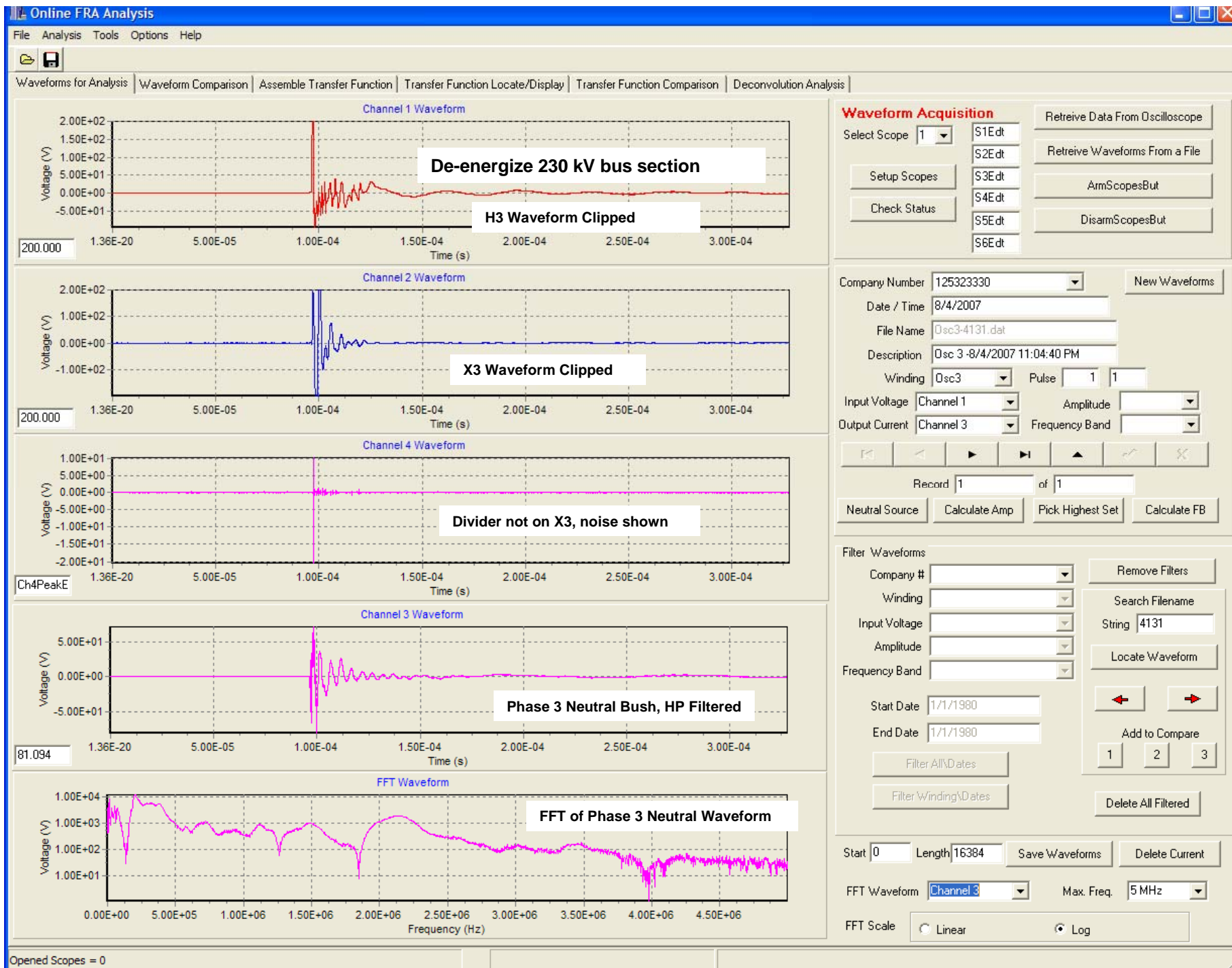
Delete Current

FFT Waveform Channel 2

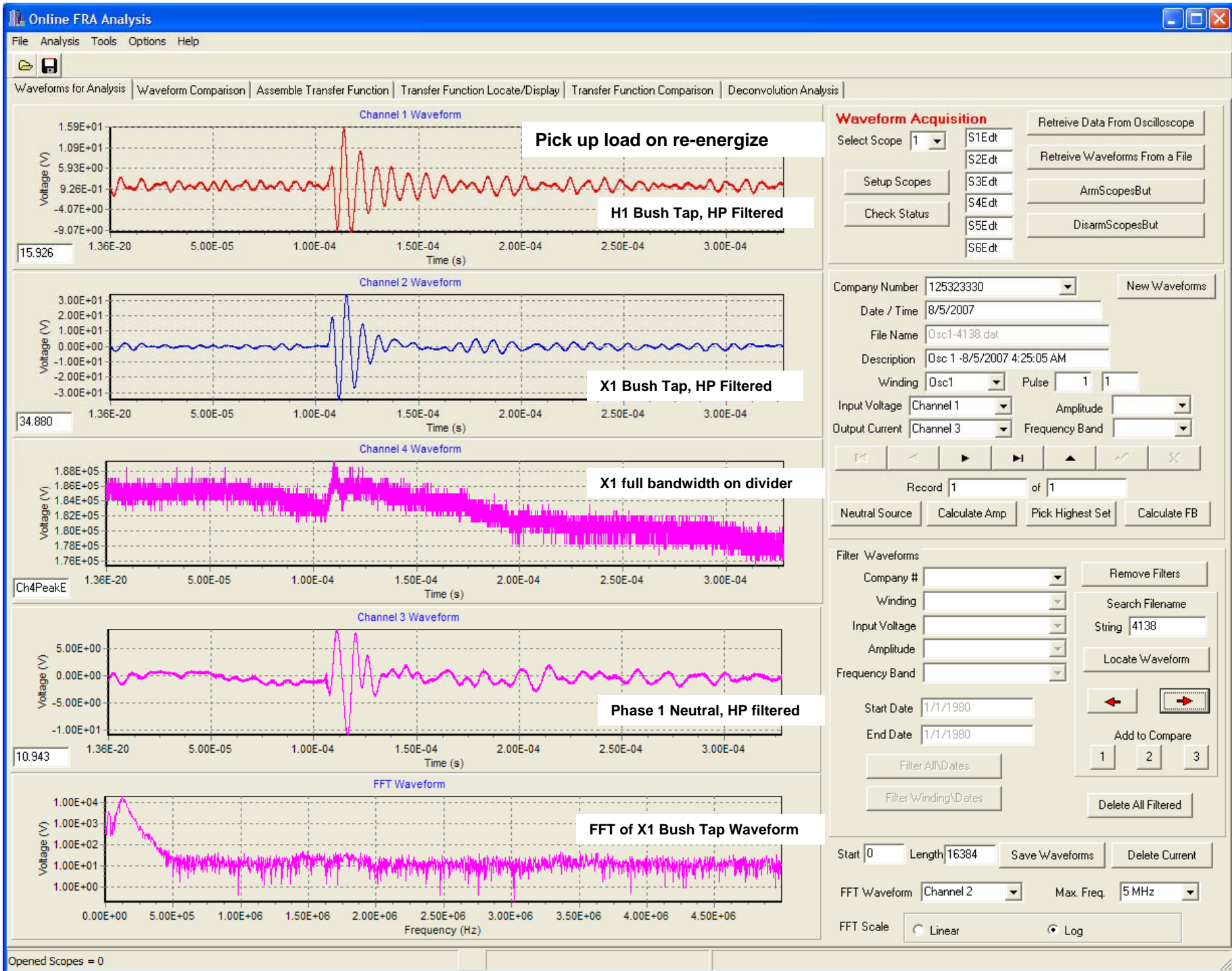
Max. Freq. 5 MHz

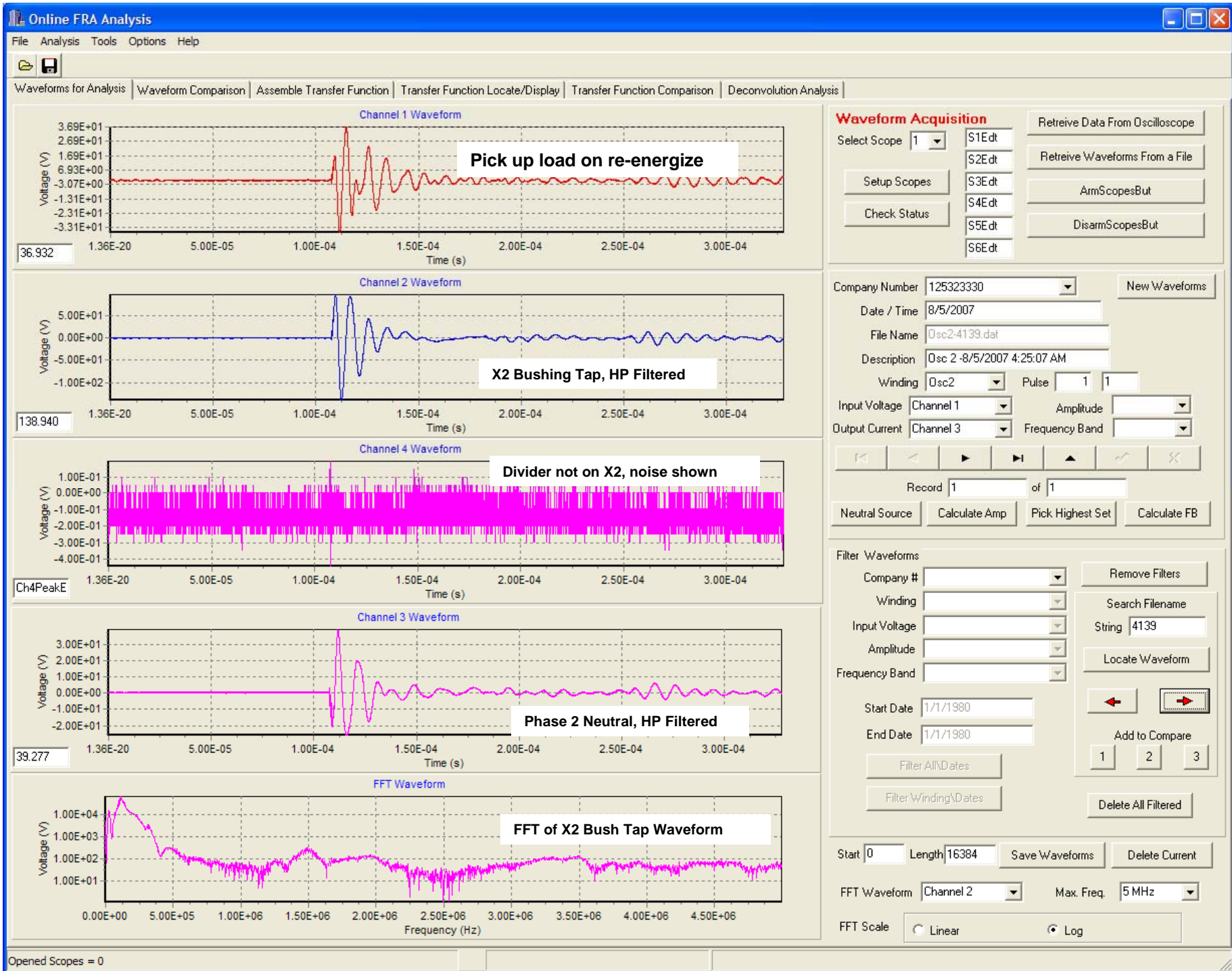
FFT Scale Linear

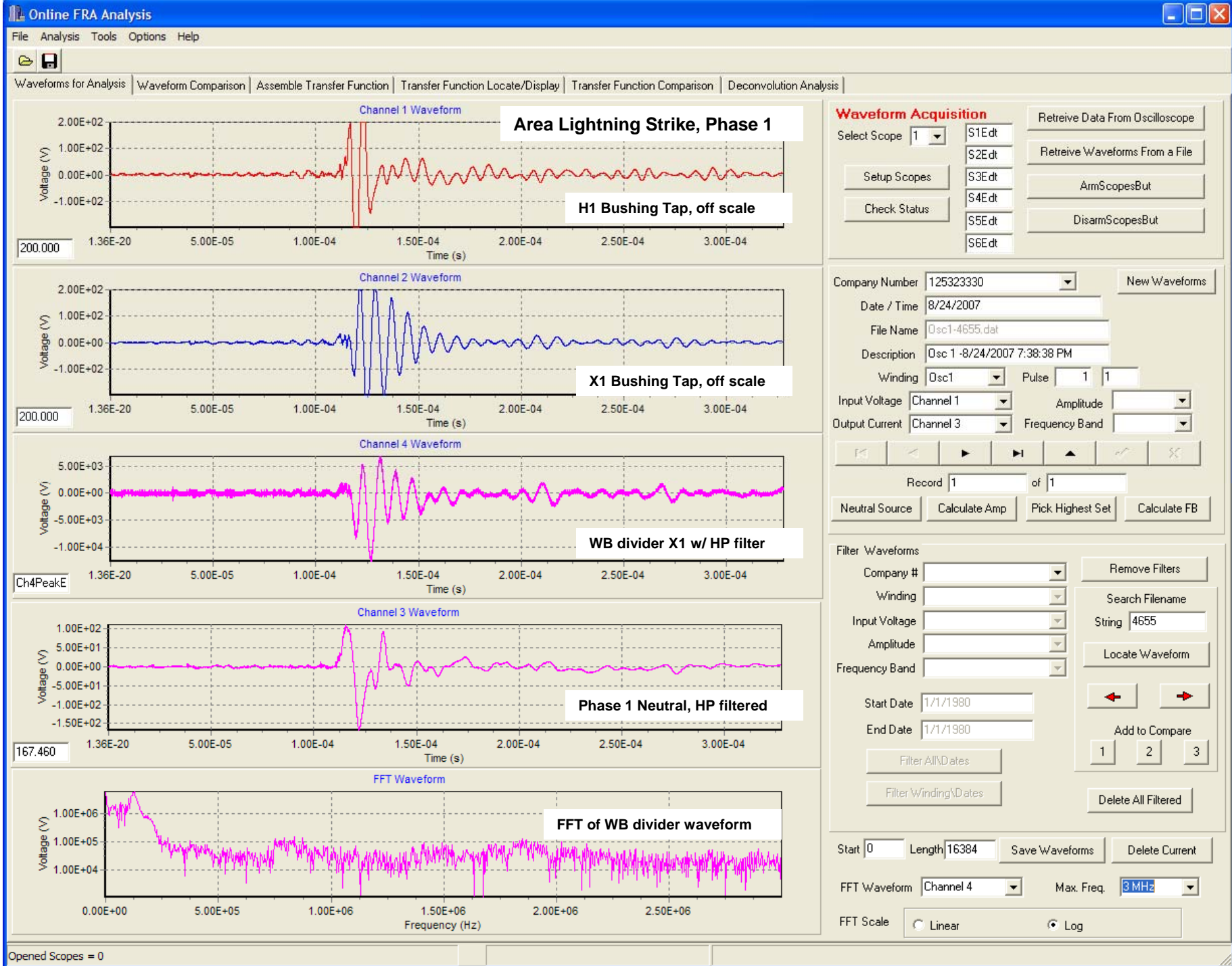
Log



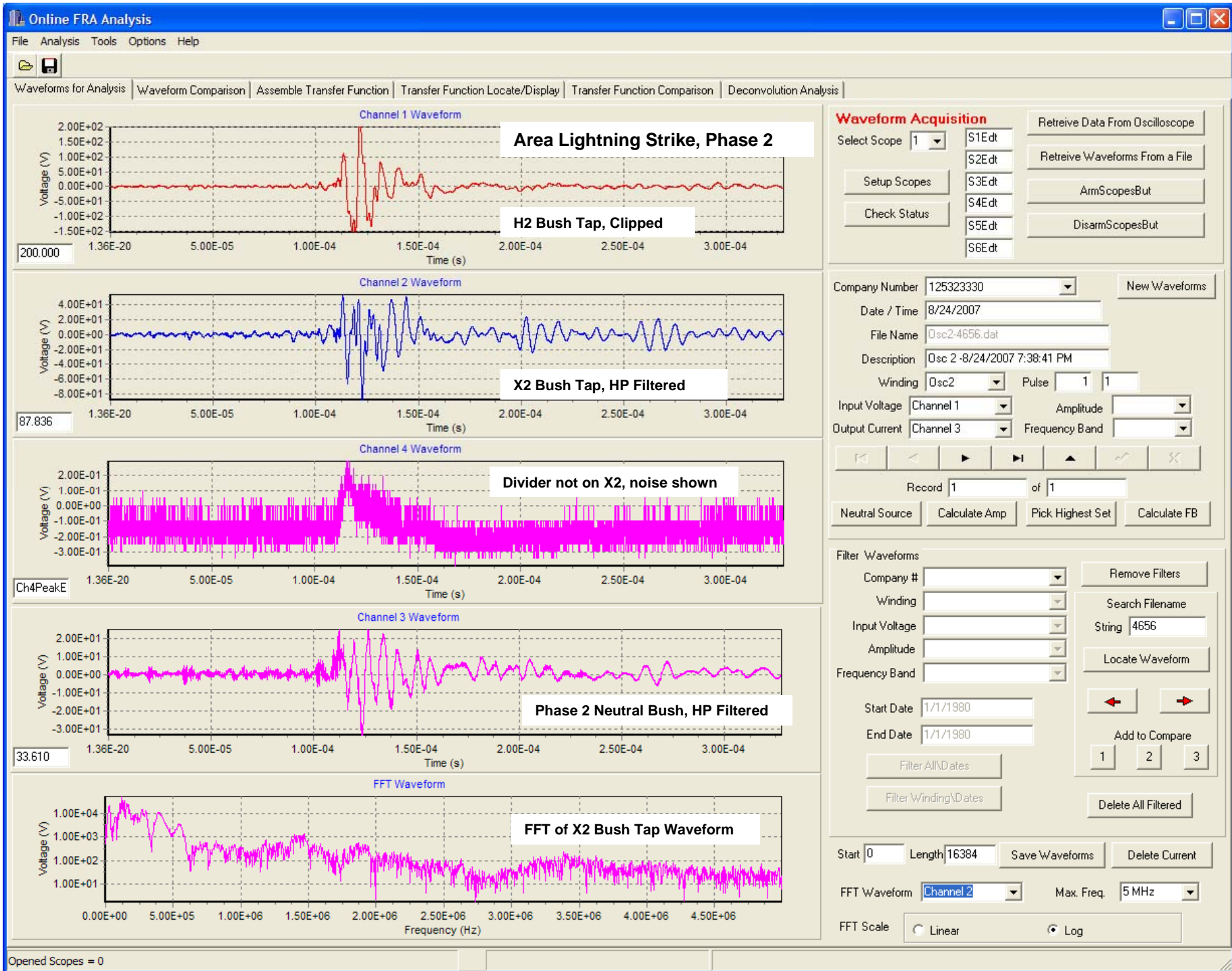


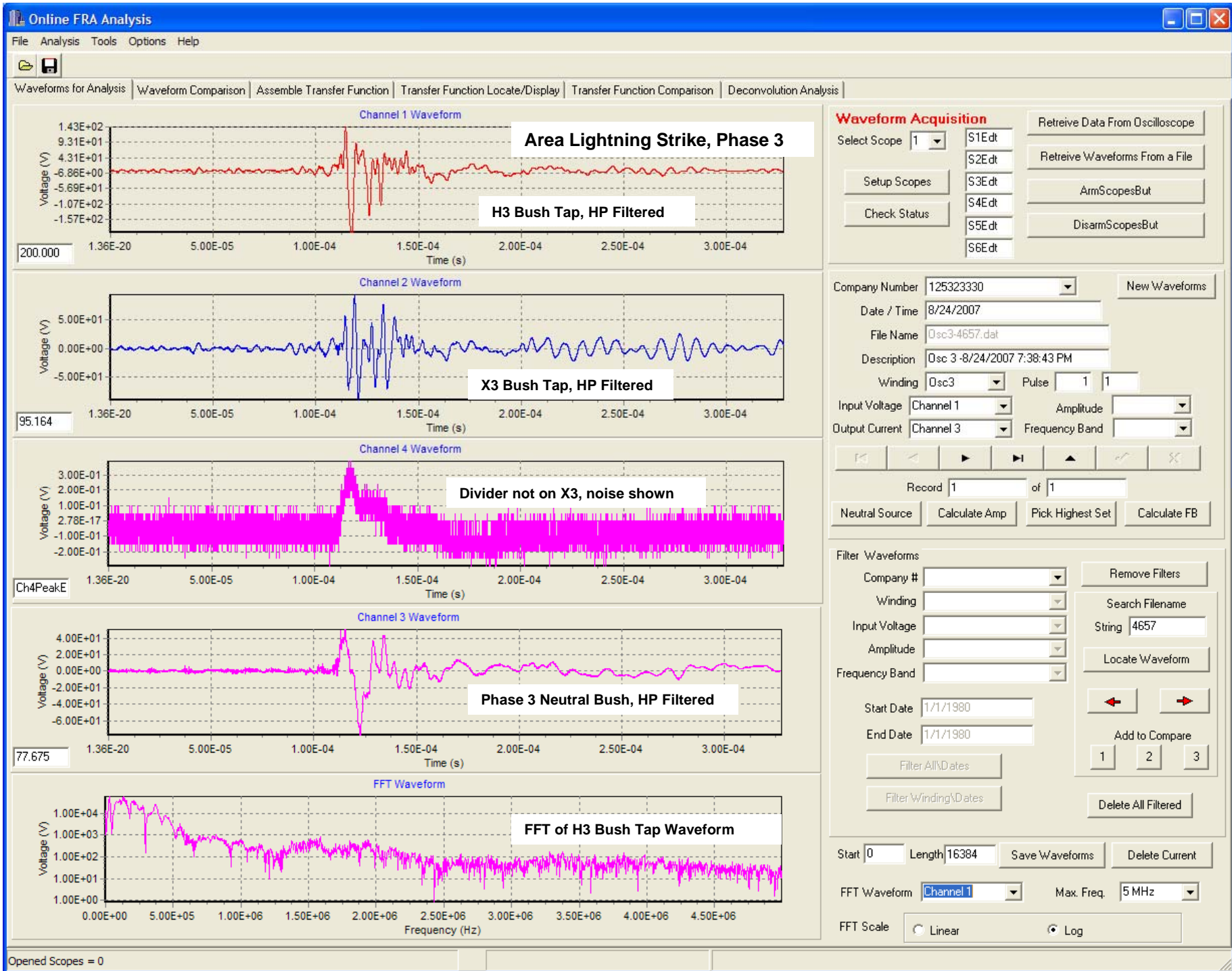












## Switching Transient **Observations** on 500 / 230 kV Auto-transformer Project to Date

- 500 / 230 kV systems can have transients present with frequency content into the MHz region.
- These transients can be generated by local switching and / or lightning.
- High frequencies can pass through a 500 / 230 kV auto with significant energy content to excite resonant frequencies in the windings.
- The TRV capacitors on the 230 kV low side breaker at the test site reduced significant transients at the transformer bushings for the normal dropping of load.
- We need to increase our dynamic range of transient recording input for the most severe transients.